

## CLAIMS

What is claimed is:

1. An apparatus (10, 26, 170, 176) for monitoring a component (16) associated with a vehicle, including:
  - a display device (22) external to the vehicle for displaying information associated with the monitoring; and
  - a monitoring device (12) in operative communication with the display device and disposed within an operative vicinity of the component being monitored for selectively sensing at least one environmental parameter associated with the component being monitored and selectively communicating data associated with the monitoring to the display device;
  - wherein the display device and the monitoring device are electrically isolated from the vehicle and the component being monitored and inoperative from equipment associated with the vehicle.
2. The apparatus as set forth in claim 1, the monitoring device including:
  - at least one environmental sensor for selectively sensing the at least one environmental parameter associated with the component being monitored and providing sensor data to the monitoring device;
  - wherein the monitoring device includes the sensor data in the data communicated to the display device.
3. The apparatus as set forth in claim 2, wherein the monitoring device is adapted to selectively transmit the data associated with the monitoring to the display device via a data communication network (18) and also adapted to receive command and control information via the data communication network.
4. The apparatus as set forth in claim 3, wherein the data communication network includes a terrestrial telephone network and a data communication satellite system, the data communication satellite system further including a data communication satellite constellation and a data communication satellite/terrestrial telephone gateway in

communication with the data communication satellite constellation and the terrestrial telephone network.

5. The apparatus as set forth in claim 4, wherein the terrestrial telephone network is a PSTN (32), the data communication satellite system is an Iridium satellite system, the data communication satellite constellation is an Iridium satellite constellation (28), and the data communication satellite/terrestrial telephone gateway is an Iridium satellite/PSTN gateway (30).

6. The apparatus as set forth in claim 3, further including:

a component information server (14) for command and control of the monitoring device, wherein the component information server is adapted to selectively transmit command and control information to the monitoring device via the data communication network, wherein the component information server is adapted to receive the data associated with the monitoring from the monitoring device via the data communication network, wherein the component information server is adapted to selectively receive command and control information from the display device via a component information network (20), wherein the component information server is adapted to selectively process the data associated with the monitoring based on preprogrammed instructions and command and control information to produce the component information associated with the monitoring, wherein the component information associated with the monitoring is selectively accessible to the display device via the component information network.

7. The apparatus as set forth in claim 6, wherein the component information network includes an Internet (36) and a data communication satellite system, the data communication satellite system further including a data communication satellite constellation and a data communication satellite/Internet gateway in communication with the data communication satellite constellation and the Internet.

8. The apparatus as set forth in claim 7, wherein the data communication satellite system is an Iridium satellite system, the data communication satellite constellation is an Iridium

satellite constellation (28), and the data communication satellite/Internet gateway is an Iridium satellite/Internet gateway (36).

9. The apparatus as set forth in claim 6, the component information server including:

- a communication link (94) adapted to receive the data associated with the monitoring and monitoring device identification data and transmit the command and control information;

- a data warehouse (96) in communication with the communication link for processing the data associated with the monitoring into component data based on a first monitoring device link between the monitoring device identification data and the component being monitored;

- a Web server (98) providing a set of Web pages for displaying the information associated with the monitoring, wherein the Web server is in communication with the data warehouse and populates at least one selected Web pages with data mined from the data warehouse;

- a client communication interface (102) in communication with the Web server and adapted to selectively provide the display device with access to the information associated with the monitoring; and

- a system controller (92) in communication with the communication link, the data warehouse, the Web server, and the client communication interface, wherein the system controller stores a predetermined monitoring device profile and controls processing of the data associated with the monitoring into component information using the predetermined monitoring device profile, wherein the system controller is adapted to command the monitoring device and provide the monitoring device with control information using the predetermined monitoring device profile.

10. The apparatus as set forth in claim 9, wherein the data warehouse produces the component data using the monitoring device identification data and the first monitoring device link and stores the component data.

11. The apparatus as set forth in claim 10, wherein the data warehouse processes the component data according to the predetermined monitoring device profile to produce at least one component report.

12. The apparatus as set forth in claim 11, the component information server further including:

a file server (100) in communication with the data warehouse and the Web server, wherein the data warehouse communicates the component reports to the file server and the file server stores the at least one component report;

wherein at least one Web page includes at least one hypertext link to the at least one component report.

13. The apparatus as set forth in claim 11, wherein the types of component reports include at least one of a group of reports, the group of reports including: i) environmental parameters associated with the component being monitored, ii) component log, and iii) operation log.

14. The apparatus as set forth in claim 9, wherein the data warehouse produces element data using the monitoring device identification data and the first and second monitoring device links and stores the element data, wherein the second monitoring device link identifies a relationship between the component and the element.

15. The apparatus as set forth in claim 14, wherein the element is any one of a group of elements, the group of elements including: an aircraft tail number, an operator, a crew member, a vehicle owner, a fuel pump manufacturer, an engine manufacturer, and a vehicle manufacturer.

16. The apparatus as set forth in claim 14, wherein the component is a fuel pump and the element is an engine.

17. The apparatus as set forth in claim 9, wherein the Web server is adapted to present information associated with the monitoring to an authorized client user via the Web pages and to respond to client user selections and requests presented via the Web pages.

18. The apparatus as set forth in claim 9, wherein the component information server is adapted to communicate with a client user associated with the component via the component information network to configure the first monitoring device link.

19. The apparatus as set forth in claim 9, wherein the first monitoring device link includes monitoring device link information, wherein the monitoring device link information includes at least one of a group of information types, the group of information types including: i) component identification data, ii) component certification, iii) component operational information, and iv) component maintenance information.

20. The apparatus as set forth in claim 6, wherein the preprogrammed instructions include a predetermined monitoring device profile and the component information server is adapted to communicate with a client user associated with the component via the component information network to configure the predetermined monitoring device profile according to predetermined monitoring requirements for the component.

21. The apparatus as set forth in claim 6, wherein the preprogrammed instructions include a predetermined monitoring device profile, wherein the component information server is adapted to transmit the preprogrammed instructions to the monitoring device via the data communication network, wherein the monitoring device is adapted to receive the preprogrammed instructions via the data communication network.

22. The apparatus as set forth in claim 21, wherein the predetermined monitoring device profile includes at least one of a group of control information items associated with the fuel pump, the group of control information items including: i) component information to be monitored and frequency, ii) vibration thresholds associated with startup and shutdown of an engine associated with the vehicle, iii) vibration thresholds associated with normal

movement of the vehicle, iv) high stress conditions, v) fuel and fuel consumption information, and vi) reports to be processed and report frequency.

23. The apparatus as set forth in claim 3, the monitoring device including:

- a data communication link (48) adapted to transmit data via the data communication network and adapted to receive data via the data communication network;

- a storage device (72) for storing the data associated with the monitoring, a monitoring device identification data, and a predetermined monitoring device profile;

- a controller (68) in communication with the data communication link and the storage device, wherein the controller controls data transmissions in a burst fashion by waiting for a group of the data associated with the monitoring to accumulate in the storage device based on the predetermined monitoring device profile and commands received via the data communication network, wherein the controller includes the monitoring device identification data in each data transmission burst.

24. The apparatus as set forth in claim 23, wherein the controller controls the timing between transmission bursts to maintain a virtual private network connection over a public data communication system within the data communication network.

25. The apparatus as set forth in claim 24, wherein the public data communication system is the Iridium satellite system.

26. The apparatus as set forth in claim 23, wherein the controller controls the timing between transmission bursts so that the apparatus can provide real-time information associated with the monitoring.

27. The apparatus as set forth in claim 23, wherein the controller controls the timing between transmission bursts to minimize transmission time over the data communication network.

28. The apparatus as set forth in claim 23, wherein the controller delays a transmission burst until a begin transmitting command is received via the data communication network.

29. The apparatus as set forth in claim 23, wherein the controller maintains the combined position and time data in the storage device associated with each transmission burst until an acknowledgment of receipt of the transmission burst is received via the data communication network.

30. The apparatus as set forth in claim 2, wherein the monitoring device is adapted to selectively receive position and time data from multiple global positioning system satellites (240) of a global positioning system satellite constellation (24), the position data representing a position of each global positioning system satellite from which data was received with respect to center of Earth (37) and the time data representing a time of day associated with the position data, the monitoring device being disposed at a location facilitating reception of the position and time data, the monitoring device combining the position and time data from the multiple global positioning system satellites and the sensor data to for the component data associated with the component being monitored.

31. The apparatus as set forth in claim 30, the monitoring device including:

- a global positioning system receiver (65) adapted to selectively receive the position and time data, wherein the monitoring device includes the position and time data in the data communicated to the display device;

- a storage device (72) for selectively storing the data associated with the monitoring and detected event data; and

- a controller (68) in communication with the at least one environmental sensor, global positioning system receiver, and storage device, wherein the controller combines the position and time data received by the global positioning system receiver in a trilateration fashion to produce XYZ and time data when the position and time data was received from at least four global positioning satellites, the XYZ data representing a latitude, a longitude, and an altitude, respectively, and the time data representing a time of day associated with the XYZ data, the combined position and time data including the XYZ and time data, wherein the controller includes the combined position and time data in the data communicated to the display device.

32. The apparatus as set forth in claim 31, wherein the resolution of the XYZ data is about 18 inches in latitude, about 18 inches in longitude, and about 18 inches in altitude.

33. The apparatus as set forth in claim 31, wherein the controller compares the XYZ data to predetermined XYZ coordinate limits to detect at least one of a group of events, the group of events including: i) component being monitored is nearing a high stress condition, ii) component being monitored is experiencing a high stress condition, iii) component being monitored is experiencing excessive loss of altitude, iv) component being monitored is experiencing excessive increase in altitude, and v) fuel pump is experiencing unexpected stoppage/slow down.

34. The apparatus as set forth in claim 33, wherein the at least one environmental sensor begins sensing the at least one environmental parameter, the global positioning system receiver begins receiving the position and time data, and the controller begins storing the data associated with the monitoring and the detected event data in the storage device when at least one of the group of events are detected.

35. The apparatus as set forth in claim 33, wherein the monitoring device begins transmitting the data associated with the monitoring and the detected event data from the storage device when at least one of the group of events are detected.

36. The apparatus as set forth in claim 31, wherein the at least one environmental sensor begins sensing the at least one environmental parameter, the global positioning system receiver begins receiving the position and time data, and the controller begins storing the data associated with the monitoring and the detected event data in the storage device when a command to begin receiving is received via the data communication network.

37. The apparatus as set forth in claim 31, wherein the monitoring device begins transmitting the data associated with the monitoring and the detected event data from the storage device when a command to begin transmitting is received via the data communication network.



38. The apparatus as set forth in claim 30, wherein the monitoring device is disposed and oriented on the component so that the monitoring device can receive position and time data from multiple global positioning system satellites during normal operation of the vehicle.

39. The apparatus as set forth in claim 2, the monitoring device further including:

a storage device (72) for selectively storing the sensor data and detected event data; and

a controller (68) in communication with the at least one environmental sensor and the storage device, wherein the controller compares measurements from the at least one environmental sensor with predetermined thresholds to detect at least one of a group of events, the group of events including: i) startup of an engine associated with the fuel pump, ii) shutdown of the engine, iii) start of movement of the vehicle, iv) cessation of movement of the vehicle, v) excessive increase in acceleration of the vehicle, and vi) excessive decrease in acceleration of the vehicle, wherein the controller selectively stores the sensor data and detected event data in the storage device.

40. The apparatus as set forth in claim 39, wherein the at least one environmental sensor includes at least one of an vibration sensor, a temperature sensor, and a strain gauge.

41. The apparatus as set forth in claim 39, wherein the at least one environmental sensor begins sensing the at least one environmental parameter and the controller begins storing the sensor data and the detected event data in the storage device when at least one of the group of events are detected.

42. The apparatus as set forth in claim 39, wherein the monitoring device begins transmitting the data associated with the monitoring and the detected event data when at least one of the group of events are detected.

43. The apparatus as set forth in claim 2, the monitoring device including:

a data communication link (48) adapted to selectively transmit the data associated with the monitoring;

a data acquisition and processing module (49) adapted to selectively receive the sensor data from the at least one environmental sensor, wherein the data acquisition and processing module is in communication with the data communication link and selectively communicates the sensor data to the data communication link; and

a power source and conversion module (47) in communication with the data communication link and the data acquisition and processing module to provide and distribute power for operation of the monitoring device, wherein the power provided includes power from a power source (50) and a backup battery (52).

44. The apparatus as set forth in claim 43, wherein the power source includes at least one of a group of power sources, the group of power sources including: a piezoelectric power generator and a primary battery.

45. The apparatus as set forth in claim 1, wherein the vehicle is one of a group including a truck, a van, an automobile, a cargo container, a trailer, a bus, a train, a locomotive, a rail car, an aircraft, and a watercraft.

46. The apparatus as set forth in claim 1, wherein the monitoring device is not accessible to operators, crew, and passengers of the vehicle during normal operation of the vehicle.

47. The apparatus as set forth in claim 1, wherein the monitoring device does not require local operator intervention during normal operation of the apparatus.

48. A fuel pump monitoring system (10, 26, 170, 176), including:

a display device (22) for displaying fuel pump information associated with a fuel pump (16) to be monitored, wherein the fuel pump is used in conjunction with a vehicle;

a fuel pump information network (20) in communication with the display device for communicating the information to the display device;

a data communication network (18);

a monitoring device (12) disposed within an operative vicinity of the fuel pump for selectively sensing at least one environmental parameter associated with the fuel pump for selectively transmitting data associated with the fuel pump via the data communication

network, wherein the monitoring device receives command and control information via the data communication network; and

a component information server (14) for command and control of the monitoring device, wherein the component information server selectively transmits command and control information to the monitoring device via the data communication network, wherein the component information server receives the data associated with the fuel pump from the monitoring device via the data communication network, wherein the component information server selectively receives command and control information from the display device via the component information network, wherein the component information server selectively processes the data associated with the fuel pump to produce the fuel pump information, wherein the fuel pump information is selectively accessible to the display device via the component information network.

49. The fuel pump monitoring system as set forth in claim 48, wherein the monitoring device is adapted to selectively receive position and time data from multiple global positioning system satellites (240) of a global positioning system satellite constellation (24), the position data representing a position of each global positioning system satellite from which data was received with respect to center of Earth (37) and the time data representing a time of day associated with the position data, the monitoring device disposed and oriented to facilitate reception of the position and time data, the monitoring device combining the position and time data from the multiple global positioning system satellites with the sensor data to for the data associated with the fuel pump.

50. The fuel pump monitoring system as set forth in claim 48, wherein the monitoring device is electrically isolated from the fuel pump and inoperative from equipment associated with the fuel pump.

51. The apparatus as set forth in claim 48, the monitoring device including:

an environmental sensor (66) for sensing at least one of vibration, temperature, and surface strain associated with the fuel pump;

a storage device (72) for selectively storing the sensor data and detected event data; and

a controller (68) in communication with the environmental sensor and storage device, wherein the controller compares vibration measurements from the environmental sensor with predetermined thresholds to detect at least one of a group of events, the group of events including: i) startup of an engine associated with the fuel pump, ii) shutdown of the engine, iii) start of movement of the vehicle, iv) cessation of movement of the vehicle, v) excessive increase in acceleration of the vehicle, and vi) excessive decrease in acceleration of the vehicle, wherein the controller selectively stores the sensor data and the detected event data in the storage device.

52. The apparatus as set forth in claim 48, wherein the data communication network includes a land line terrestrial telephone network and a wireless terrestrial telephone system, the wireless terrestrial telephone system further including a wireless terrestrial telephone network and a wireless terrestrial telephone/land line terrestrial telephone gateway in communication with the wireless terrestrial telephone network and the land line terrestrial telephone network.

53. The apparatus as set forth in claim 48, wherein the data communication network includes a wireless LAN (178), a wire line LAN (182), and a wireless/wire line LAN hub (180) in communication with the wireless LAN and the wire line LAN (182).

54. The apparatus as set forth in claim 48, wherein the component information network includes an Internet (34) and a land line telephone network in communication with the Internet.

55. The apparatus as set forth in claim 48, wherein the component information network includes a wire line LAN (180).

56. A method for monitoring a fuel pump associated with a vehicle and providing fuel pump information to a subscriber, including the steps:

a) associating the subscriber with a monitoring device and the monitoring device with the fuel pump, wherein the monitoring device is disposed in an operative vicinity of the fuel pump at a location in which the monitoring device can receive position and time

data from multiple global positioning system satellites and sense at least one environmental parameter associated with the fuel pump during normal operation of the vehicle, wherein the monitoring device is electrically isolated from the vehicle and the fuel pump and inoperative from equipment associated with the vehicle;

b) granting the subscriber using a display device access to a Web site via a component information network, wherein the Web site includes at least one fuel pump information Web page that displays a map suitable for monitoring environmental parameter, position, and time data associated with the fuel pump;

c) receiving position and time data from at least four global positioning system satellites of a global positioning system satellite constellation at the monitoring device, the position data representing a position of each global positioning system satellite from which data was received with respect to center of Earth and the time data representing a time of day associated with the position data;

d) sensing at least one environmental parameter associated with the fuel pump;

e) communicating the environmental parameter, position, and time data to a component information server via a data communication network;

f) processing the position and time data in a trilateration fashion to produce XYZ and time data, the XYZ data representing a latitude, a longitude, and an altitude, respectively, and the time data representing a time of day associated with the XYZ data;

g) displaying the environmental parameter, XYZ, and time data on the at least one Web page and overlaying a symbol on the map at a coordinate associated with the XYZ data; and

h) repeating steps c) through g) for a predetermined time at a predetermined interval.

57. The apparatus as set forth in claim 56, wherein the data communication network includes a PSTN, an Iridium satellite constellation, and an Iridium satellite/PSTN gateway in communication with the PSTN and the Iridium satellite constellation, wherein the monitoring device is in communication with the Iridium satellite constellation and the tracking information is displayed to the subscriber at the display device when the fuel pump is substantially anywhere in the world with line of sight access to the sky.

58. The apparatus as set forth in claim 56, wherein the component information network includes an Internet, an Iridium satellite constellation, and an Iridium satellite/Internet gateway in communication with the Internet and the Iridium satellite constellation, wherein the display device is in communication with the Iridium satellite constellation and the tracking information is displayed to the subscriber at the display device when the subscriber is substantially anywhere in the world.